DISASTER RISK PROFILE

Flood Drought

Botswana (Republic of)

Building Disaster Resilience in Sub-Saharan Africa

Building Disaster Resilience to Natural Hazards in Sub-Saharan African Regions, Countries and Communities

An initiative of the African, Caribbean and Pacific Group of States funded by the European Union

This project is funded by the European Union

UNISDR
The United Nations Office for Disaster Risk Reduction

cima
RESEARCH FOUNDATION

International Centre on Environmental Monitoring
Via Magliotto 2. 17100 Savona. Italy
August 2018

Africa Disaster Risk Profiles are co-financed by the EU-funded ACP-EU Natural Disaster Risk Reduction Program and the ACP-EU Africa Disaster Risk Financing Program, managed by UNISDR.

Via Armando Magliotto, 2 - 17100 Savona - Italy;
Phone: +39 019230271 - Fax: +39 01923027240
E-mail: info@cimafoundation.org
www.cimafoundation.org

Design and layout: CIMA Research Foundation
Printing: Jollygraf, Italy
Video Production: Don't Movie, Italy

In collaboration with:

PROJECT TEAM

Authors
Roberto Rudari [1]
Sjaak Conijn [3]
Silvia De Angeli [1]
Hans de Moel [2]
Luca Ferraris [1;4]
Elisabetta Fiori [1]
Tatiana Ghizzoni [1]
Isabel Gomes [1]
Marco Massabò [1]
Lauro Rossi [1]
Eva Trasforini [1]

Scientific Team
Nazan An [6]
Chiara Arrighi [1;5]
Valerio Basso [1]
Guido Biondi [1]
Alessandro Burastero [1]
Lorenzo Campo [1]
Fabio Castelli [1;5]
Mirko D'Andrea [1]
Fabio Delogu [1]
Giulia Ercolani [1;5]
Simone Gabellani [1]
Alessandro Masoero [1]
Ben Rutgers [3]
Franco Siccardi [1]
Francesco Silvestro [1]
Andrea Tessore [1]
Tufan Turp [6]
Marthe Wens [2]

Editing and Graphics
Silvia De Stefano [1]
Rita Visigalli [1]

Supporting Team
Simona Pozzati [1]
Luisa Colla [1]
Monica Corvarola [1]
Iain Logan [7]
Rich Parker [8]
Elisa Poggi [1]
Martino Prestini [1]

With the support of the UNISDR Regional Office for Africa

CIMA Research Foundation [1]
Vrije Universiteit Amsterdam [2]
Wageningen University & Research [3]
Università di Genova [4]
Università di Firenze [5]
Bogazici University [6]
GEG [7]
Training in Aid [8]

INDEX

INTRODUCTION

Disasters are on the rise, both in terms of frequency and magnitude.
From 2005-2015, more than 700 thousand people worldwide have lost their lives due to disasters that have affected over 1.5 billion people, with women, children and people in vulnerable situations disproportionately affected. The total economic loss was more than US$ 1.3 trillion. Disasters inordinately affect lower-income countries. Sub-Saharan Africa, where two-thirds of the world's Least Developed Countries are located, is prone to recurrent disasters, largely due to natural hazards and climate change.

The Sendai Framework for Disaster Risk Reduction 2015 – 2030 emphasises the need to manage risk rather than disasters, a theme already present in its predecessors, the Yokohama Strategy and the Hyogo Framework for Disaster Risk Reduction. Specifically, the Sendai Framework calls for strong political leadership, commitment, and involvement of all stakeholders at all levels from local to national and international, with a view to *"prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political, and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience".*

Understanding disaster risk is the Sendai Framework's first priority for action: *"policies and practices for disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment".* The outputs of disaster risk assessment should be the main drivers of the disaster risk management cycle, including sustainable development strategies, climate change adaptation planning, national disaster risk reduction across all sectors, as well as emergency preparedness and response.

As part of the programme "Building Disaster Resilience to Natural Hazards in Sub-Saharan African Regions, Countries and Communities", UNISDR engaged CIMA Research Foundation for the preparation of 16 Country Risk Profiles for Floods and Droughts for the following countries: Angola, Botswana, Cameroon, Equatorial Guinea, Gabon, Gambia (Republic of The), Ghana, Guinea Bissau, Kenya, Eswatini (Kingdom of), Ivory Coast, Namibia, Rwanda, São Tomé and Príncipe, Tanzania, and Zambia.

The Country Risk Profiles provide a comprehensive view of hazard, risk and uncertainties for floods and droughts in a changing climate, with projections for the period 2050-2100. The risk assessment considers a large number of possible scenarios, their likelihood, and associated impacts. A significant amount of scientific information on hazard, exposure, and vulnerabilities has been used to simulate disaster risk.

The EU PROGRAMME "Building Disaster Resilience to Natural Hazards in Sub-Saharan African Regions, Countries and Communities"

In 2013, the European Union approved 80 million EUR financing for the programme *"Building Disaster Resilience to Natural Hazards in Sub-Saharan African Regions, Countries and Communities"*. The programme is being implemented in Africa by four partners: the African Union Commission, the United Nations Office for Disaster Risk Reduction (UNISDR), the World Bank's Global Facility for Disaster Reduction and Recovery (WB/GFDRR), and the African Development Bank's ClimDev Special Fund (AfDB/CDSF). The programme provides analytical basis, tools and capacity, and accelerates the effective implementation of an African comprehensive disaster risk reduction and risk management framework.

PROBABILISTIC RISK PROFILE: METHODOLOGY

PROBABILISTIC RISK ASSESSMENT

Understanding disaster risk is essential for sustainable development. Many different and complementary methods and tools are available for analysing risk. These range from qualitative to semi-quantitative and quantitative methods: probabilistic risk analysis, deterministic or scenario analysis, historical analysis, and expert elicitation.

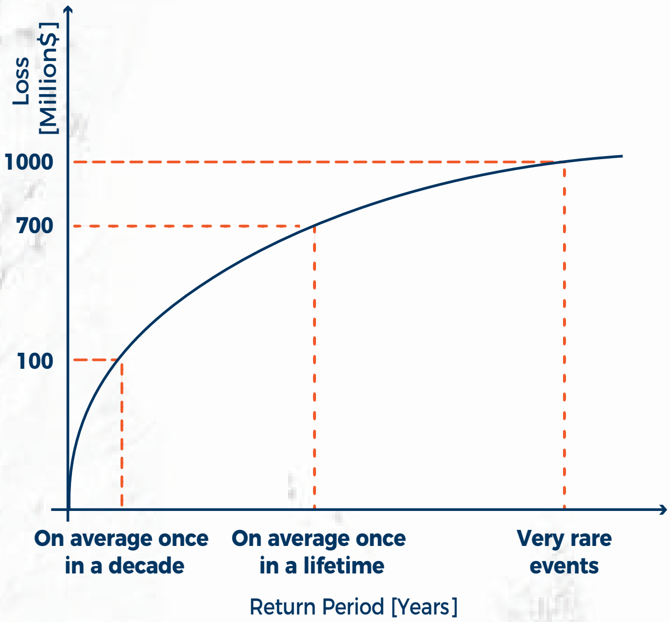
This disaster risk profile for floods and droughts is based on probabilistic risk assessment. Awareness of possible perils that may threaten human lives primarily derives from experience of past events. In theory, series of historical loss data long enough to be representative of all possible disastrous events that occurred in a portion of territory would provide all necessary information for assessing future loss potential. Unfortunately, the availability of national historical information on catastrophic natural hazard events is limited, and data on the economic consequences is even less common.

In the absence of extensive historical data, a modelling approach is needed to best predict possible present and future scenarios, taking into consideration the spatial and temporal uncertainties involved in the analysed process. This profile simulates a realistic set of all possible hazardous events (scenarios) that may occur in a given region, including very rare, catastrophic events. Potential impacts were computed for each event, taking into consideration associated economic losses or number of people and assets affected. Publicly available information on hazard, exposure, and vulnerability was used in the analysis. Finally, statistics of losses were computed and summarised through proper quantitative economic risk metrics, namely Annual Average Loss (AAL) and Probable Maximum Loss (PML).
In computing the final metrics (PML, AAL), the uncertainties that permeate the different steps of the computations have been explicitly quantified and taken into account: uncertainties in hazard forcing, uncertainties in exposure values and their vulnerabilities.

Average Annual Loss (AAL) is the expected loss per year, averaged over many years. While there may actually be little or no loss over a short period of time, AAL also accounts for much larger losses that occur less frequently. As such, AAL represents the funds which are required annually in order to cumulatively cover the average disaster loss over time.

Probable Maximum Loss (PML) describes the maximum loss which could be expected corresponding to a given likelihood. It is expressed in terms of annual probability of exceedance or its reciprocal, the return period. For instance, in the figure below, the likelihood of a US$ 100 million loss is on average once in a decade, a loss of US$ 1 billion is considered a very rare event. Typically, PML is relevant to define the size of reserves which, insurance companies or a government should have available to manage losses.

The methodology is also used to simulate the impact of climate change [SMHI-RCA4 model, grid spacing 0.44° - about 50 km - driven by ICHEC-EC-EARTH model, RCP 8.5, 2006-2100 and, future projections of population and GDP growth (SSP2, OECD Env-Growth model from IIASA SSP Database)].
Results are disaggregated by different sectors, using the categories of Sendai Framework indicators: direct economic loss (C1), agricultural sector (C2), productive asset and service sector (C3), housing sector (C4), critical infrastructures and transportation (C5).

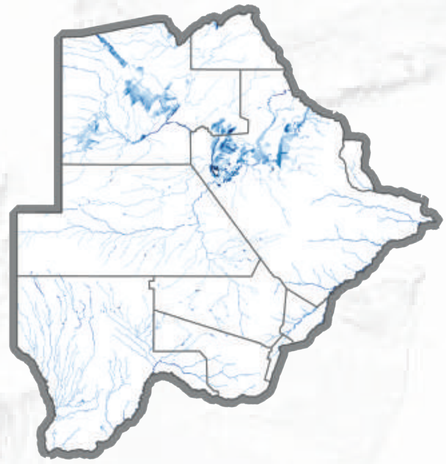


PROBABILISTIC RISK PROFILE: RISK COMPONENTS

HAZARD

process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.

In order to best predict possible flood and drought scenarios, a modelling chain has been composed of climate, hydrological, and hydraulic models using all the available information, including rainfall, temperature, humidity, wind, and solar radiation. A set of mutually exclusive and collectively exhaustive possible hazard scenarios that may occur in a given region or country has been generated and expressed in terms of frequency, extension of the affected area and intensity at different locations.



Flood hazard map for 1 in a 100 years probability evaluated under current climate conditions, the scale of blues represents different water depth values.

VULNERABILITY

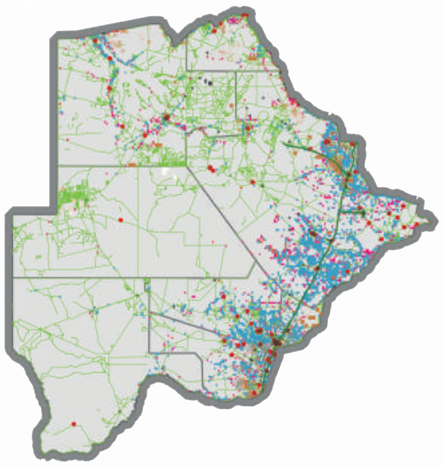
conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

Direct losses on different elements at risk are evaluated applying vulnerability functions. This links hazard intensity to the expected loss (economic loss or number of affected people) while counting for associated uncertainty. Vulnerability functions are differentiated for each typology of exposed elements and take into account local factors, such as typical constructive typologies for infrastructures or crop seasonality for agricultural production. In the case of flooding, vulnerability is a function of water depth. This is with the exception of agricultural production, for which vulnerability is a function of the season in which a flood occurs. In the case of agricultural drought, losses are computed in terms of lack of production for different crops from a nominal expected production. A similar approach is used for hydrological drought, the evaluation of which focusses on loss of hydropower production.

EXPOSURE

people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses.

Losses caused by floods and droughts are assessed in relation to population, GDP and a series of critical sectors (education, health, transport, housing, and productive and agricultural sectors). Critical sectors are created clustering all of the components, which contribute to a specific function (e.g. the health sector is comprised of hospitals, clinics and dispensaries). Thoroughly generated publicly available global and national data enables a localization of these elements at high resolution, e.g. 90 metres or lower, for the whole country. The total number of people and the National GDP (in US$) are considered in both current (2016) and future (2050) scenarios. The critical sectors are characterised in terms of their economic value (in US$), using the most updated information available.



Exposure distribution, the different colors represent different types of assets.

UNISDR terminology on Disaster Risk Reduction: https://www.unisdr.org/we/inform/publications/7817

COUNTRY CLIMATE OUTLOOK

OVERVIEW

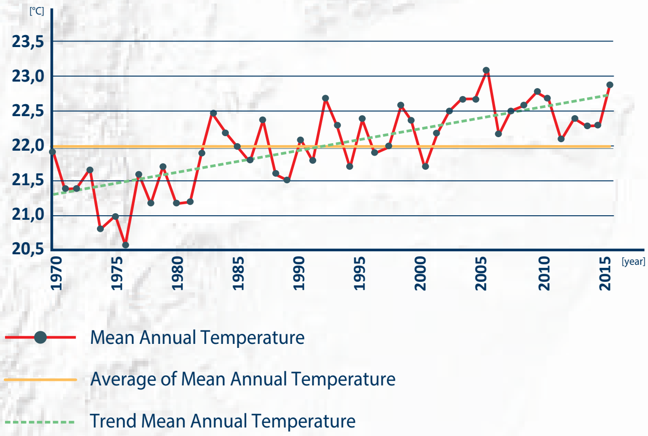
Botswana has a semi-arid climate with hot and dry conditions for most of the year; the dry season is exacerbated in winter time from May to August. Precipitations are concentrated during the summer rainy season from November to March [1]. Three agro-ecological zones can be distinguished in the country [2]:

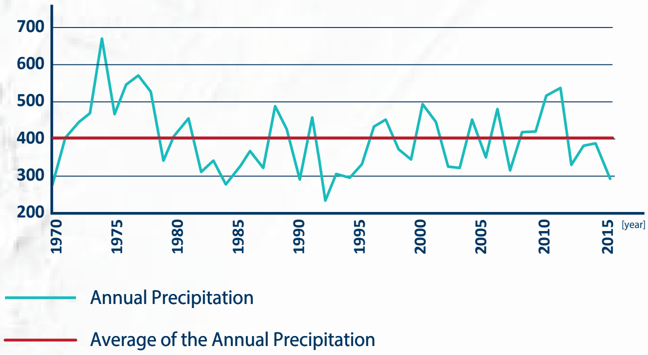
- Centre and West: the Kalahari Desert covers over two-thirds of the total area. Although it has low rainfall, the predominant landscape is not desert as savannah grasslands interspersed with woodland. The sandy soils are not well suited for cultivation, but support considerable numbers of cattle, goats, other livestock and wildlife.
- East: The predominant landscape is savannah grasslands and woodlands, with a small amount of forest. The climate is less harsh than the Kalahari and the soil is more fertile. Annual rainfall is generally exceeds 400 mm.
- Northwest: the area is predominantly covered by Okavango Delta and Makgadikgadi pans. Okavango delta presents vast areas of open water and lushwetlands with an abundance of wildlife. Makgadikgadi Pans have vast, flat and salty depressions.

CLIMATE TRENDS

Similarly to other Southern African countries, temperature observations indicate that Botswana has experienced a considerable increase in temperature over recent years. An analysis of climate data from 1970 to 2015 [3] shows an average rise of temperature by around 1.5 °C. Trends for precipitation are not as clear as those for air temperatures and they vary in time and space. The average annual precipitation for Botswana is approximately 400 mm, while the mean number of wet days is around 53.

TEMPERATURE AND PRECIPITATION TRENDS IN CURRENT CLIMATE





RIVERS OF THE REPUBLIC OF BOTSWANA

Botswana is drained by a complex system of multiple trans-boundary rivers which originate either in South Africa or in Angola. The Molopo, Limpopo and Nossop are in the south and mark the country's border with South Africa. Most of these rivers dry up in the summer, but during the monsoon season they frequently flood their banks [4,5] . During the rainy season, the Limpopo river becomes navigable.

The northern part of the country has some unique rivers: the Chobe, a tributary of the great Zambezi River, the Linyanti at the border with Zambia and the Okavango. The Okavango delta is the world's largest inland delta. The Makgadikgadi Pan is a salt pan situated in the middle of the dry savanna of north-eastern Botswana and it counts among the largest salt flats in the world.

http://www.botswanatourism.co.bw/explore/okavango-delta

CLIMATE PROJECTIONS FOR THE REPUBLIC OF BOTSWANA

Climate projection studies are abundant for multiple time spans and multiple scales. Climate models are tools that the scientific community uses to assess trends in weather conditions over long periods. In a recent study, Alder, et al.[6], have compared the observed temperature and precipitations for the period 1980-2004 with estimations of a set of global climate models provide by the Coupled Model Intercomparison Project Phase 5 (CMIP5). Three future periods (2025-2049, 2050-2074 and 2071-2095) have been analysed for different greenhouse emission scenarios (see IPPC's Emissions Scenarios).

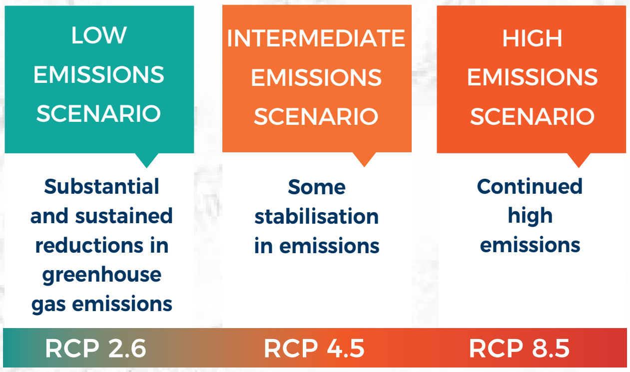
For all three periods, models show an increase in temperature for all emission scenarios and both for short and for long term periods. Temperature increase is more evident in high emissions scenarios and long-term period projections. In high emission scenarios (RCP8.5) for the mid-term period (2050-2074), model projections show a temperature increase between 3˚C and 4˚C and an increase between about 4˚C and 5,5˚C for the long term period (2071-2095). Future changes in precipitation are much more uncertain; however the models predict a decrease in precipitation for both the medium and long-term period and for all different emission scenarios.

Time Frame	Climate Projections (RCP 8.5 - High emission scenario)
Mid-term Future (2050-2074)	Increase in temperature from 3˚C to 4˚C Very likely decrease in precipitation (up to 25%)
Far Future (2071-2095)	Increase in temperature from 4˚C to 5.5˚C Very likely decrease in precipitation (up to 25%)

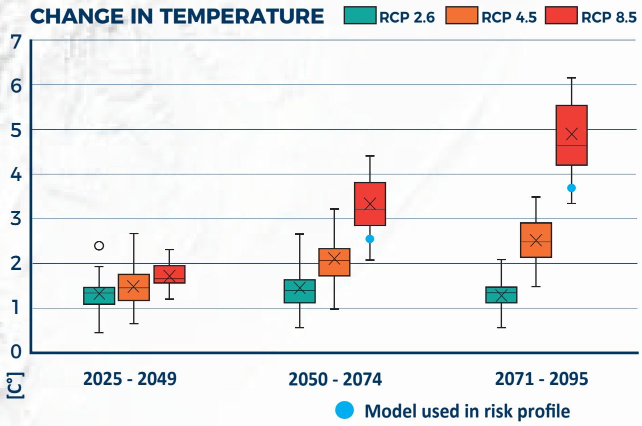
CLIMATE PROJECTIONS USED IN THIS RISK PROFILE

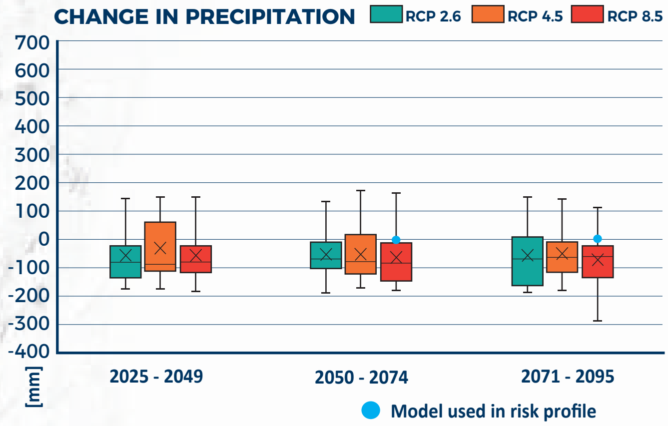
Results refer to climate change presented in this Risk Profile were obtained using a climate projection model based on a high emission scenario (SMHI-RCA4 model, grid spacing 0.44˚ about 50 km- driven by the ICHEC-EC-EARTH model, RCP 8.5, 2006-2100) [7,8,9].

This study uses a high-resolution model which has been accurately calibrated for the African domain. This allows for a better capture of climate variability which is key in assessing extremes. Regional model projections were checked for consistency against a full ensemble of global models available for the area. The Regional model forecasts changes in temperature and annual precipitation. These are in line with the range of variability of global models analyzed in the study by Alder et al. [6].



IPCC's Emissions scenarios for Climate Projections





For the specific case of high emission scenario, the Regional model predicts a more moderate increase in temperature (almost 4˚C in the long term period) when compared to the global ensemble. With regard to annual precipitation at country level, only some minors changes are predicted by the Regional model in the long-term period.

COUNTRY SOCIO-ECONOMIC OUTLOOK

OVERVIEW

Landlocked in the centre of the southern African subcontinent, Botswana is a vast tableland on an undulating plateau with a mean altitude of 1,000 meters. It has a population of about 2.4 million (UN estimation for 2018 [10]).

After the 1966 independence, the Republic of Botswana saw rapid development and became classified as an upper middle-income country. The national GDP increased on average about 5% per annum over the past decade with a peak between 2008 and 2011. Economic activity is expected to intensify in the future and be mostly driven by mining activity, construction, the service sector and intensified public investment [11]. Economic reliance on commodities renders the country vulnerable to international market fluctuations.

Despite Botswana's economic performance, the country faces high levels of poverty, unemployment (up to 18%). Income inequality in the country is one of the world's highest. Inequality and poverty is exacerbated in rural areas and in the southern part of the country [12].

SOCIO-ECONOMIC PROJECTIONS

Climate scientists and economists have recently built a range of new "pathways" to examine ways in which national and global societies, demographics and economics may lead to alternative plausible future development scenarios over the next one hundred years [13,14]. Such scenarios range from optimistic, indicating positive trends in human development with "substantial investments in education and health, rapid economic growth and well-functioning institutions" [15], to more pessimistic outlooks for low-income countries, indicating low levels of economic and social development, limited investment in education or health, coupled with fast-growing populations and increasing inequalities.

PROJECTIONS USED IN THE RISK PROFILE

The "middle of the road" scenario envisages no extraordinary societal changes and that historic development patterns will persist throughout the 21st century. The results of this risk profile report use this scenario. According to this scenario, the 2050 population of Botswana will increase by roughly 20% compared to the population in 2016 (World Bank Data). National GDP is expected to increase more than five-fold.

POPULATION	GDP
2016 Projection	2016 Projection
2.2	15.6
[Million People]	[Billion$]
2.7	88.6
2050 Projection	2050 Projection

BOTSWANA

AREA : 566.730 km²

POPULATION DENSITY : 4 people/km²

MEDIAN AGE : 24.7 years

HDI - HUMAN DEVELOPMENT INDEX : 0.717

LIFE EXPECTANCY AT BIRTH : 67.6 years

MEAN YEARS OF SCHOOLING : 9.3 years

EMPLOYMENT TO POP. RATIO (AGES > 15) : 58.9%

EMPLOYMENT IN AGRICULTURE : 26.2%

EMPLOYMENT IN SERVICES : 60.3%

data from:
http://hdr.undp.org/en/countries/profiles/
https://data.worldbank.org/indicator/
http://www.worldometers.info

A "SENDAI DRIVEN" PRESENTATION

The Sendai Framework guides the organisation of the risk profile results.

The first page of results reports the annual average number of people affected by flood. This indicator refers to Sendai Framework Target B: "Substantially reduce the number of affected people globally by 2030" and specifically to Sendai indicator B1: "Number of directly affected people attributed to disasters".

In the following pages, other indicators that contribute to Sendai Framework Targets C and D are reported.

A series of indicators that contribute to increasing knowledge of the country on Sendai Framework Target C: "Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030" are considered. Specifically, the indicator C1 "Direct economic loss attributed to disasters" is computed as a compound index, obtained as a sum of several indicators computed in our fully probabilistic risk methodology. These single indicators can be reconciled to the Sendai Target C indicators.

In the flood results section, the following Target C indicators are addressed in the second page:

·C2 Direct agricultural loss attributed to disasters (based on different return periods. the main crops).
·C3 Direct economic loss to all other damaged or destroyed productive assets attributed to disasters. In this risk profile, C3 is split into two components: productive assets (industrial buildings and energy facilities) and service sector (governmental and service buildings).
·C4 Direct economic loss in the housing sector attributed to disasters.
·C5 Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters. In this risk profile C5 is split into two components: transportation systems (roads and railways) and other critical infrastructures (health and education facilities).

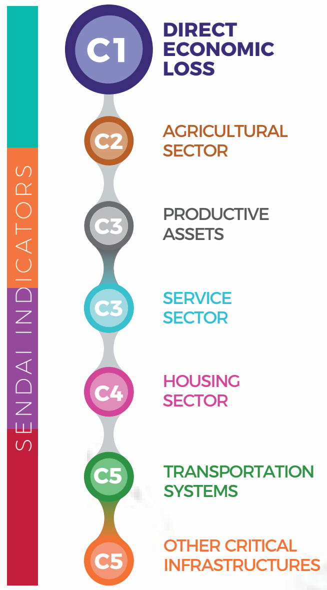
Inside the same page (the second of flood results), Sendai Framework Target D: "Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030" is addressed providing the count of affected critical infrastructures (e.g. health and education facilities and kilometres of transportation network).

In the third page of results for floods, the most relevant sectors for the country are selected and their AAL distribution is presented in present and future climate conditions in relation to the exposure distribution considered in the study. The results are broken down on the fourth and final page according to different return periods and presented in terms of PML curve of the total damage across all sectors. The contribution of the different sectors is highlighted in each range of return periods of the total damage.

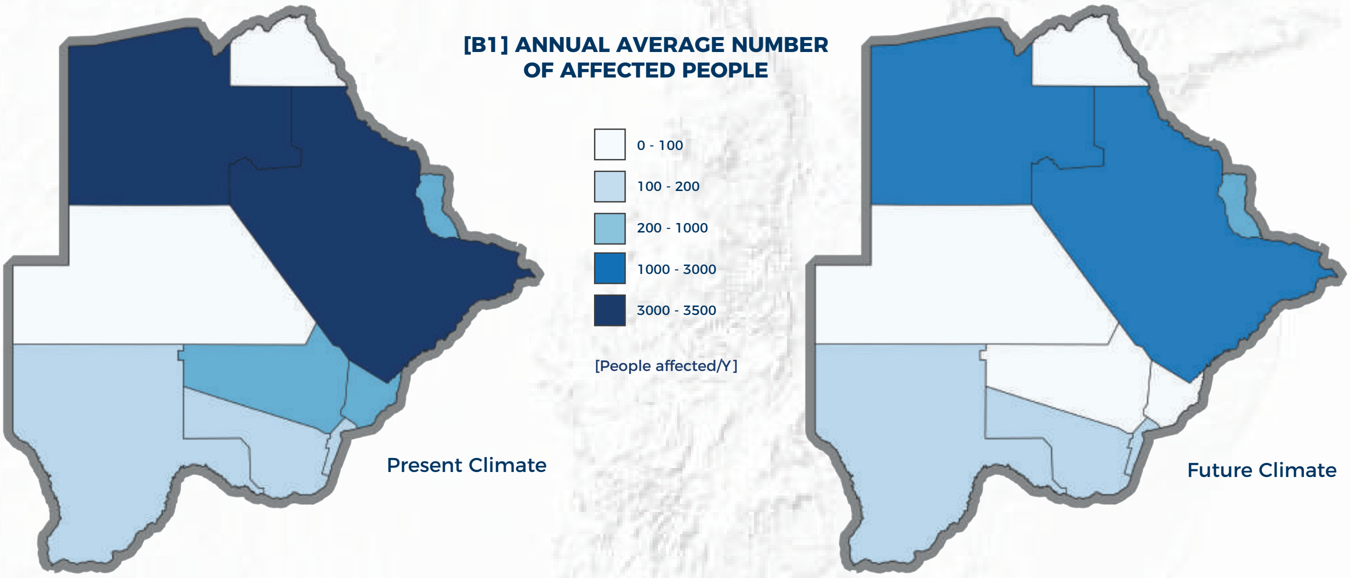
In the drought results section, the second page reports the spatial distribution of main effects on livestock units, and direct agricultural (crop) losses; the latter map can be associated to indicator C2. In addition, agricultural production loss is also broken down into crop types, and the annual average number of working days lost in agricultural sectors is shown.

In the third page, two indicators related to Target C are reported:
· C1 Direct economic loss
· C2 Direct agricultural loss attributed to disasters (based on the main crops)
· C3 Direct economic loss to all other damaged or destroyed productive assets attributed to disasters. In these calculations, only hydropower losses are assessed in the context of drought.

In the fourth page, the spatial distribution of some drought indicators is shown.



RESULTS | FLOODS



KEY MESSAGES

● Flooding is an impacting natural hazard in Botswana affecting yearly an average of 8.000 people which equates to approximately 0.4% of the total population of the country.

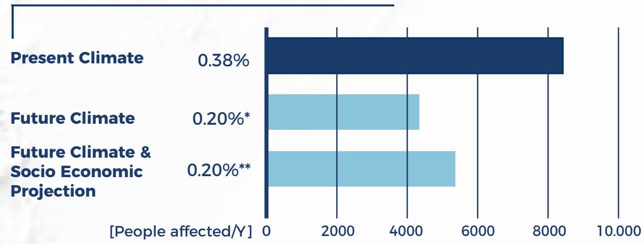
● A majority of the affected people are concentrated in the central district, which is the most populous district, and in Ngamiland, where the delta of the Okavango river is located.

● The local economy is highly exposed to floods. On average about 90 mln USD of GDP per year can be potentially affected by floods. This correspond to about 0.56% of the total yearly GDP at country level.

● As climate models predict a significative increase in temperature and a likely decrease of precipitation, the flood affected population as well as potentially affected GDP are likely to decreases under future climate conditions and compared to the values evaluated under current climate conditions. However, as shown in the climate session, climate projections are inherently uncertain. This uncertainty requires consideration when the above estimations are used in policy development.

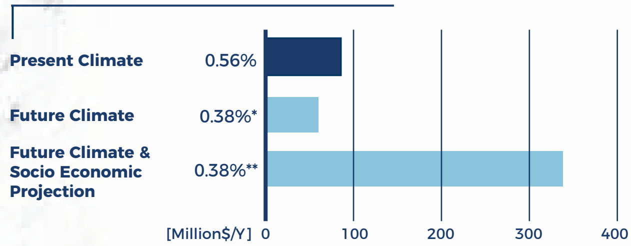
● When the affected population and GDP under current climate conditions are compared with estimates under future climate conditions and when they are paired with projected socio-economic situation (*), they show a betterment. Namely, the flood affected population decreases in future conditions and the GDP increases. This is a result of the disproportional growth projected for the population and the GDP (population increase of about 30% and GDP by 5-fold)**. The future prediction is highly uncertain.

ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED PEOPLE [B1]



* % computed with reference to the total 2016 Population
** % computed with reference to the total 2050 Population

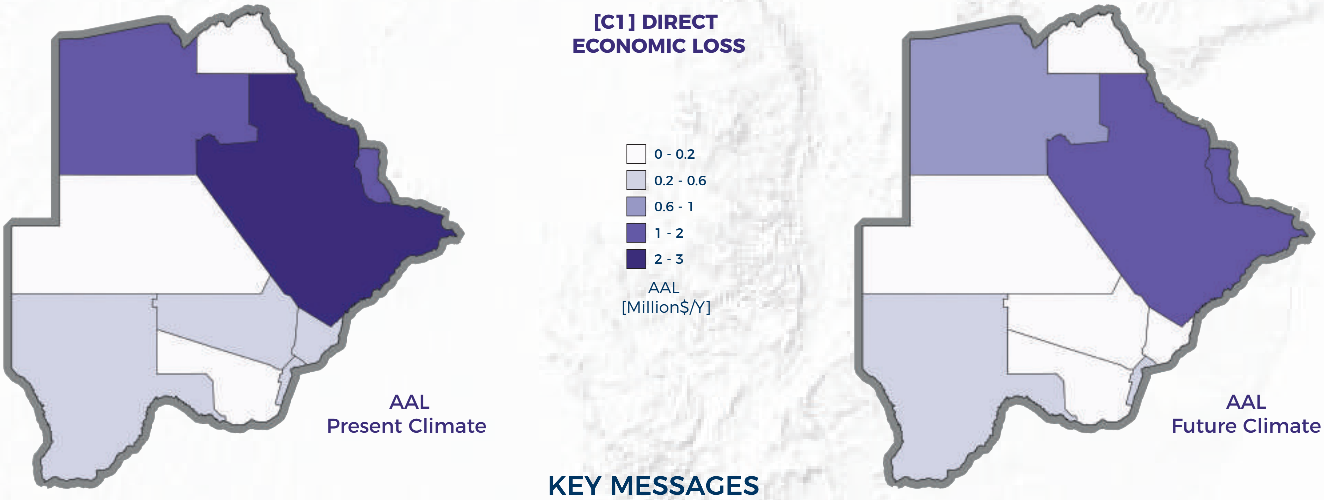
ANNUAL AVERAGE POTENTIALLY AFFECTED GDP



* % computed with reference to the total 2016 GDP
** % computed with reference to the total 2050 GDP

*2016 was taken as a reference year both for GDP and population.
**the Shared Socioeconomic Pathway (SSP) - 2 "mid of the road" (Medium challenges to mitigation and adaptation) has been used to project population and GDP distributions.

RESULTS | FLOODS



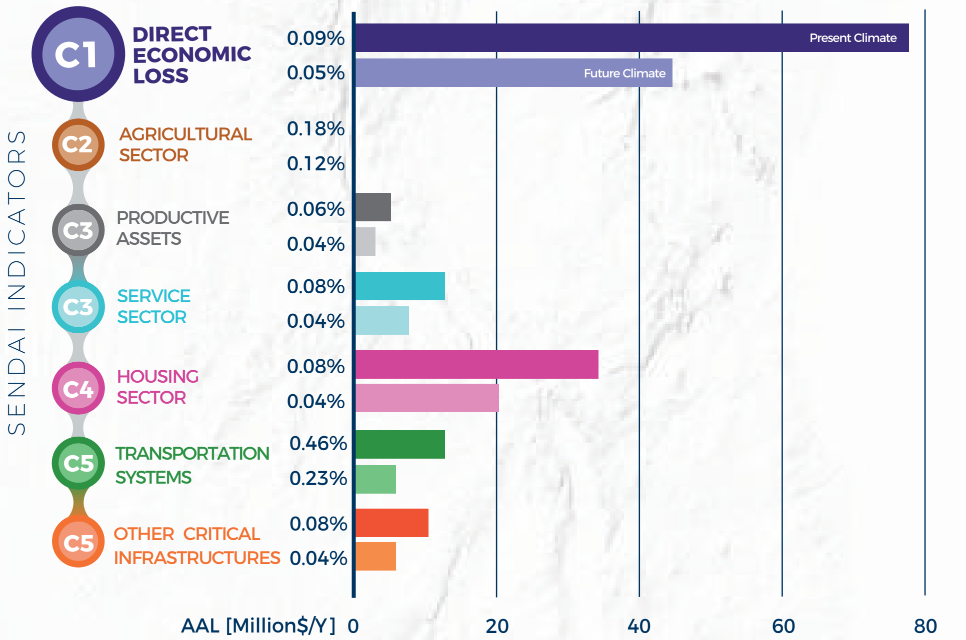
KEY MESSAGES

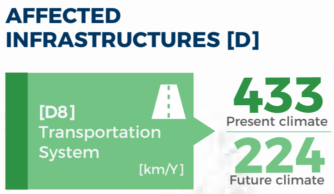
- Direct economic losses in Botswana concentrate in the central district and in the Ngamiland district. The pattern, although with reduced values, is confirmed in the future climate.

- Direct annual economic losses sum up to 75 millions of USD, which accounts roughly to 0.1 percent of the total exposure value under present climate. The larger portion of losses is incurred in three sectors - housing, service and transportation.

- Considering the present exposed assets for all sectors, it is likely that average annual losses will decrease under future climate conditions,. However, this estimation does not consider socio-economic projections that can possibly overturn the future projections.

- The proportion of different sectors in the overall loss does not change under future climate conditions. As highlighted above, climate projections are inherently uncertain and this should be considered when using these estimations in policy development.



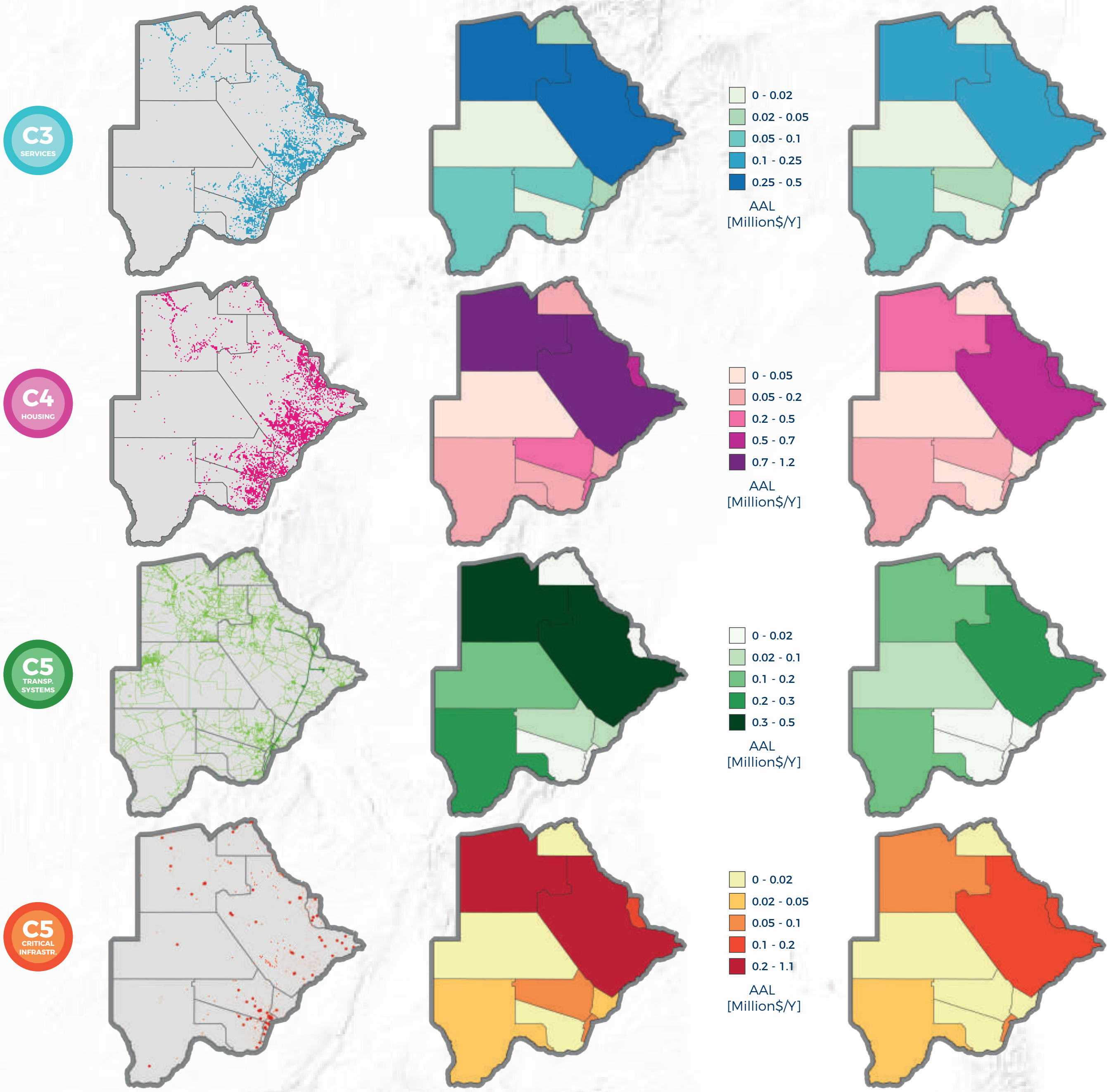


RESULTS | FLOODS

KEY MESSAGES

- The AAL distribution for Productive Assets confirms the exposure distribution with hotspots in central and Ngamiland districts for all sectors considered. the north eastern and the south eastern district show remarkable losses despite their limited extension.
- Comparison of AALs for all sectors between present and future climate shows that it is likely to expect a decrease in economic losses. The pattern indicating a reduction in economic losses is confirmed in all sectors considered.

EXPOSURE DISTRIBUTION **AAL** - Present Climate **AAL** - Future Climate



RESULTS | FLOODS

KEY MESSAGES

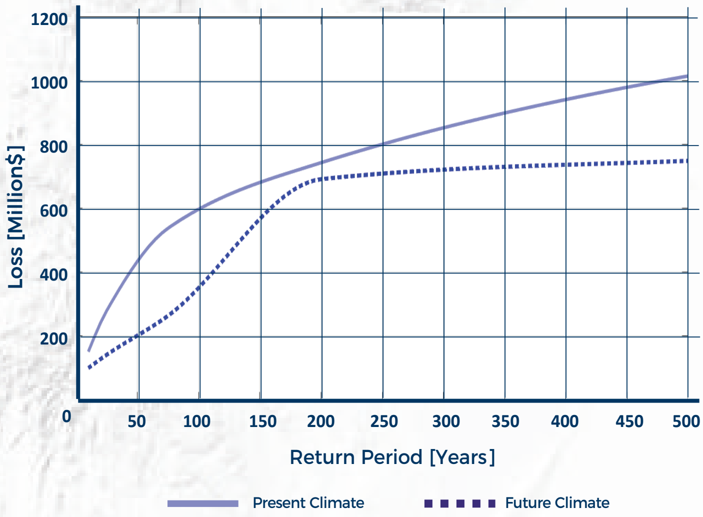
- Although Average Annual Loss is about 75 mln USD/y, the likelihood for a 200 million losses from floods is on average once a decade (every 10 years). This means that considerable losses may be experienced frequently. The likelihood of disaster losses of about 600 million USD is on average once in 100 years. Extremes losses might reach 1 billion USD.

- Sectors that are most affected by very frequent and frequent events are housing, services and transport; the losses distribution among sectors changes moving from rare to very rare events and the share of critical infrastructures tends to increase.

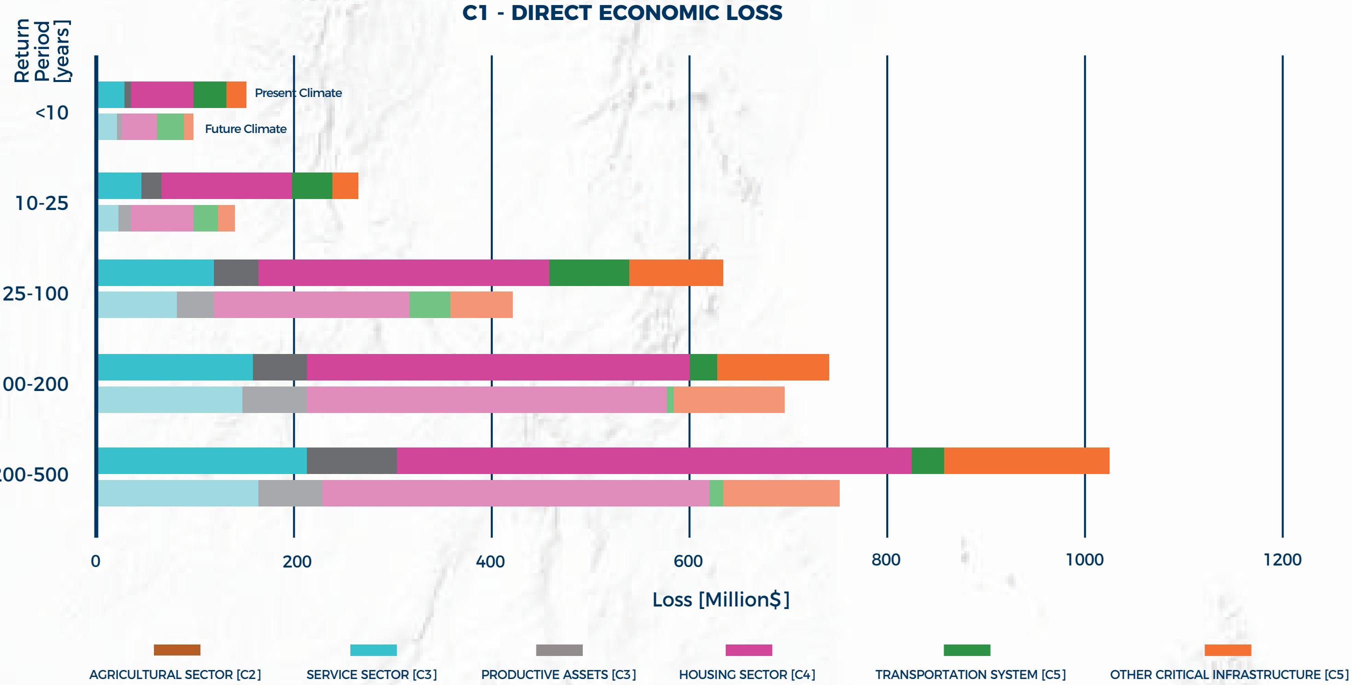
- It is likely that both frequent and extreme losses will decrease under future climate conditions and greater differences are observed for rare and very rare events. Given the high level of uncertainty in future climate prediction, worse scenarios may also be possible (compare climate section on p.8).

- The specific shape of the PML curve, shows that flood risk can be considerably reduced by strategically minimizing the impact of very frequent disaster events, hence by investing in disaster risk reduction.

PROBABLE MAXIMUM LOSS CURVE (PML)
C1 - DIRECT ECONOMIC LOSS

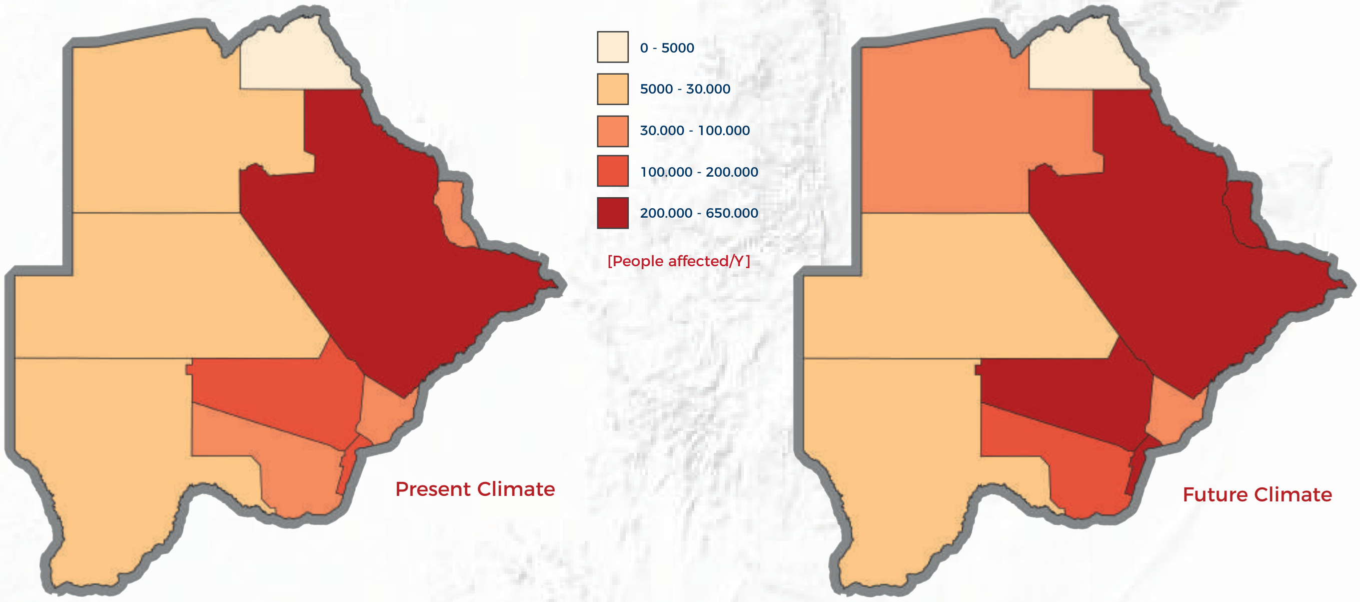


PROBABLE MAXIMUM LOSS CURVE (PML) ACROSS ALL SECTORS
C1 - DIRECT ECONOMIC LOSS



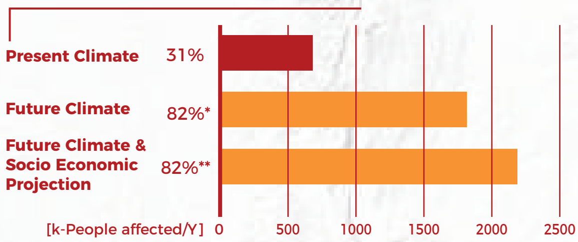
RESULTS | DROUGHTS

[B1] ANNUAL AVERAGE NUMBER OF AFFECTED PEOPLE



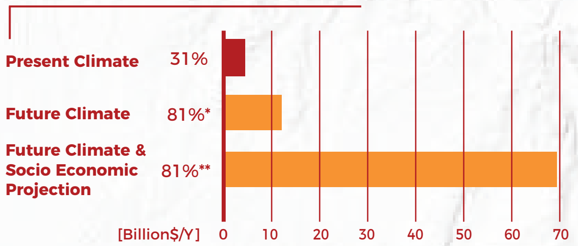
Annually average of population potentially affected by at least three months of drought conditions, as calculated using the standardized precipitation-evapotranspiration index (SPEI) and using a 3-month accumulation period.

ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED PEOPLE [B1]



* % computed with reference to the total 2016 Population
** % computed with reference to the total 2050 Population

ANNUAL AVERAGE POTENTIALLY AFFECTED GDP



* % computed with reference to the total 2016 GDP
** % computed with reference to the total 2050 GDP

KEY MESSAGES

- With respect to present conditions (1951-2000 climate), the probability of occurrence of severe effective precipitation deficiency (precipitation – evapotranspiration) will increase by 45% in the future (2050-2100 climate). It is likely that a larger share of Botswana will experience frequent droughts.

- In a present climate, on average about 687 thousand people (31% of the total 2016 Population) are annually affected by droughts. Under future climate conditions, this number is expected to increase up to 82% (on average 2.2 million people if population growth is accounted for).

- The average annual percentage of GDP affected by droughts (i.e. the economic value produced in areas hit by droughts) is about 31% of the total GDP. This is equivalent to 4.7 billion USD per year which could be impacted by droughts. Under future climate conditions, this may rise to 81% of the GDP (12 billion USD), which could amount to 70 billion USD if socio-economic projections are accounted for.

RESULTS | DROUGHTS

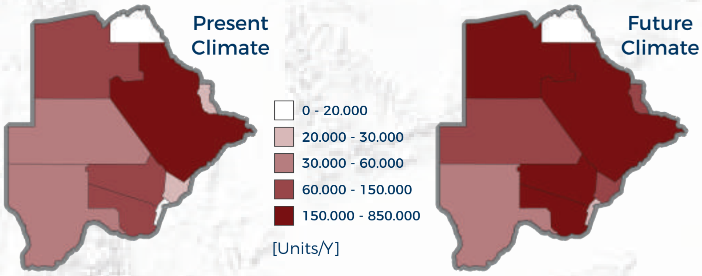
KEY MESSAGES

- Under current climate, affected livestock counts about 0.7 million livestock units (36%). Under future climate conditions (but keeping the current amount of livestock), the number of affected livestock is projected to increase up to 1.7 million units (83% of the total). Currently, most of the livestock affected by droughts is situated in the central district of Botswana, whereas under future climate condition, Ngamiland, Kweneng and Southern districts are likely to see large numbers of livestock affected by drought.

- Agricultural crop losses are dominated by roots. In relative terms, all selected crop productions, except for maize and sorghum, are strongly affected under future conditions (with increases between 2- and 7-fold compared to present climate conditions). Under future conditions, highest relative production losses are about 10% of their average crop productions for pulses and vegetables.

- Under present climate conditions, crop production losses are concentrated in the southern and eastern parts of Botswana. Under future climate conditions, losses increase in most provinces of Botswana except in the central part of the country.

- The amount of lost working days is expected to increase by more than 2 times under future climate conditions, while remaining below 1% of the average amount of working days. However, the number of working days lost, expressed as a percentage of the average amount of days required for harvesting, is approximately 12 times higher.



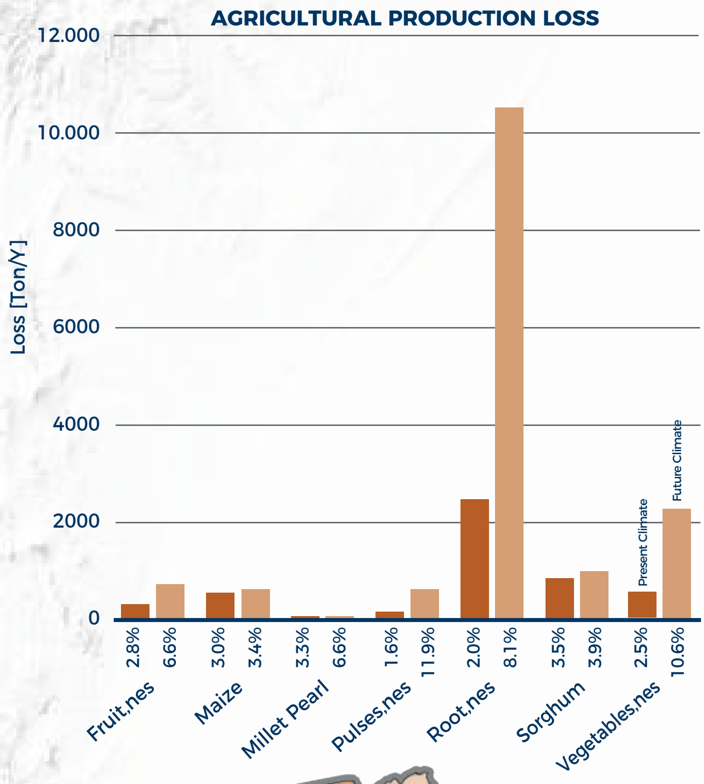
These maps show the annual average amount of livestock units hit by more than 3 months of drought conditions, based on the standardized precipitation - evapotranspiration index

ANNUAL AVERAGE NUMBER OF POTENTIALLY AFFECTED LIVESTOCK UNITS* [k-Livestock units]

710 | **36%** Present climate

1725 | **87%** Future climate

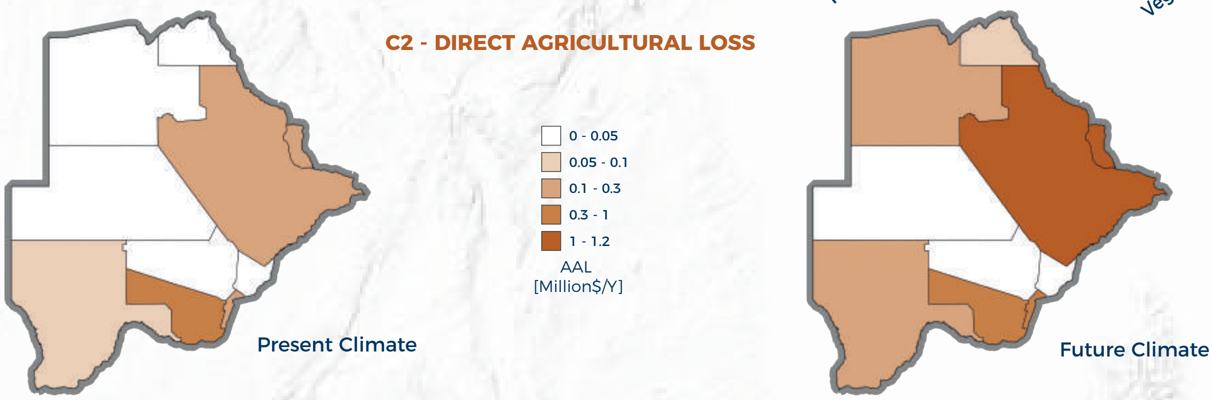
*Livestock is a summation of all livestock animals (referred to as livestock units) using FAO conversion factors



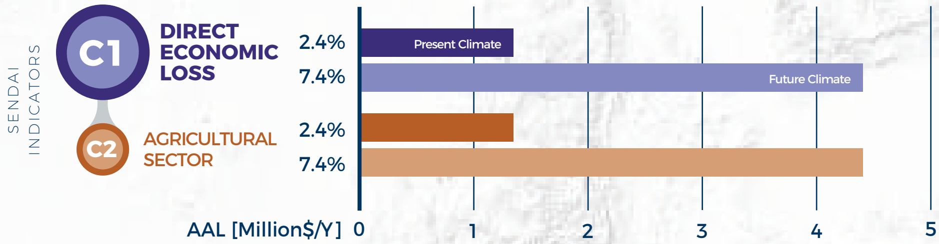
ANNUAL AVERAGE NUMBER OF WORKING DAYS LOST [k-Days]

31 | **0.28%** Present climate

70 | **0.63%** Future climate



RESULTS | DROUGHTS

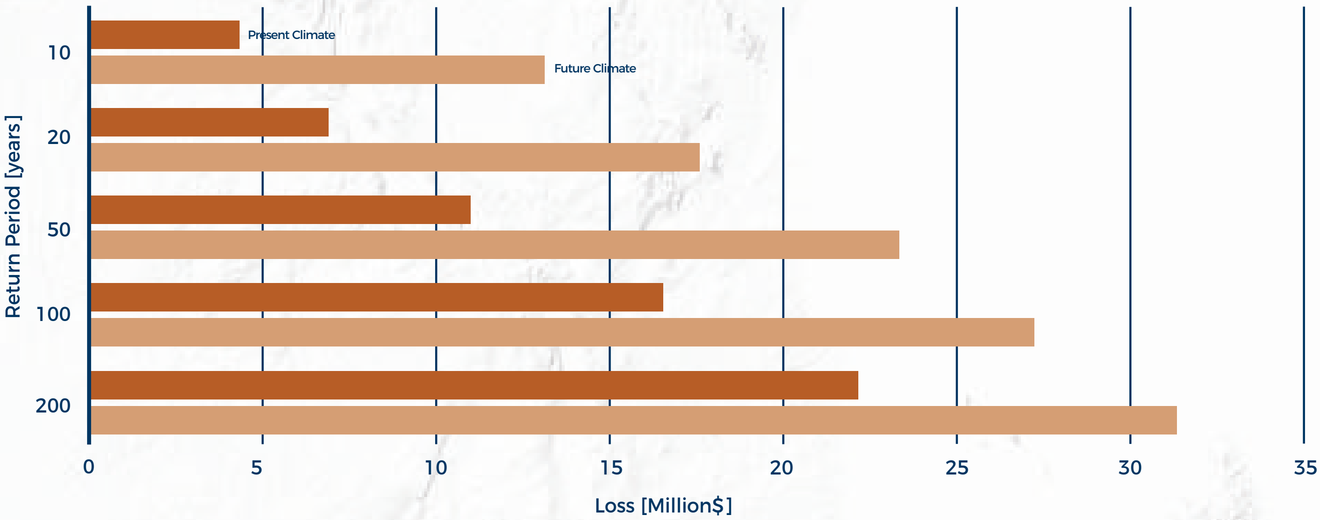


C2 is computed considering only direct loss associated with reference agricultural (crop) production. Reference crops considered in the analysis are the ones which contribute to at least 85% of the total country-level gross crop production value. It might therefore happen that crops which have an important role in local commercial or subsistence agriculture can be neglected in the overall analysis.

KEY MESSAGES

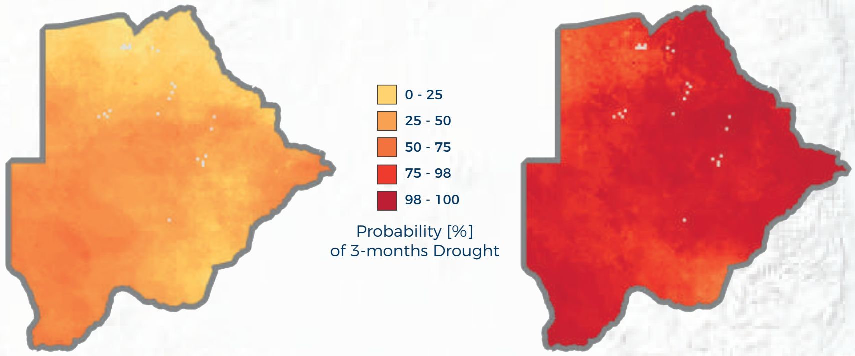
- Average annual crop production loss (C2) increases substantially (3 times) and reaches more than 4 million USD per year under future climate conditions which equals to roughly 7% of total income from crops.
- Under current climate conditions, a gradual increase in agricultural (crop) income losses is expected when return periods go up from 10 to 200 years. Under future climate conditions, and when compared to present climate conditions, agricultural income losses increase significantly. At lower return periods, the relative increase is large (e.g. approximately 3 times for a return period of 10 years).

PROBABLE MAXIMUM LOSS (PML)
C2 - AGRICULTURAL LOSS



RESULTS | DROUGHTS

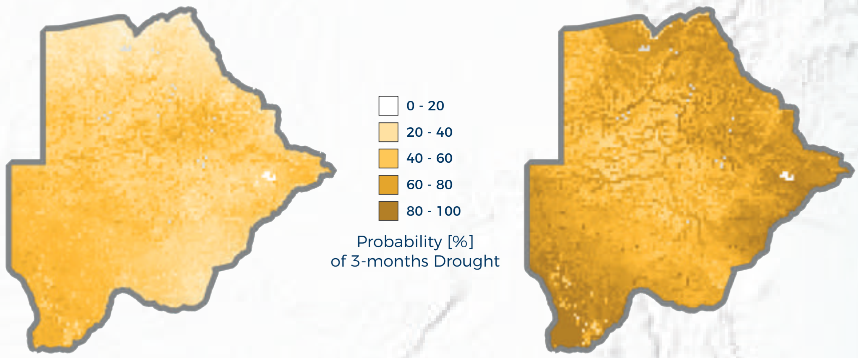
Present Climate   Future Climate



SPEI

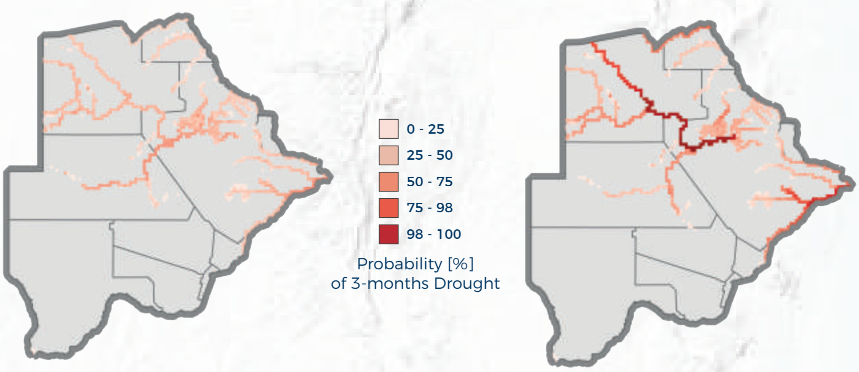
Standardised Precipitation-Evapotranspiration Index

These maps denote the average annual chance of a meteorological drought occurring (%). Droughts are defined as 3 months of precipitation minus evapotranspiration values being considerably below normal conditions. Meteorological drought is calculated through the Standardized Precipitation - Evapotranspiration Index (SPEI; see 'Drought' in Glossary). The probability of severe droughts increases over the whole country in a future climate. This is particularly important for areas dependent on rainfall for their water resources.



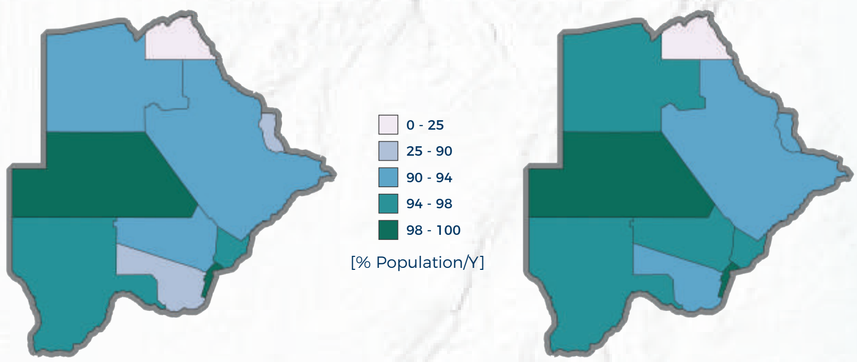
SSMI - Standardized Soil Moisture Index

These maps denote the average annual chance of a subsurface drought occurring (%). Droughts are defined as 3 months of soil moisture conditions being considerably below normal conditions. Subsurface drought is calculated through the Standardized Soil Moisture Index (SSMI; see 'Drought' in Glossary). In the south and north-east, the increase in severe droughts is expected to be the highest in a future climate. This is particularly important for agricultural areas and nature.



SSFI - Standardized Streamflow Index

These maps denote the average annual chance of a hydrological drought occurring (%). Droughts are defined as 3 months of stream flow levels being considerably below normal conditions.
Hydrological drought is calculated through the Standardized Stream Flow Index (SSFI; see 'Drought' in Glossary). Mainly the Boteti and Limpopo rivers will face a higher chance of droughts in future climate. This is particularly important for areas dependent on rivers for their water resources.



WCI - Water Crowding Index

These maps show the percentage of the population per province experiencing water scarcity, based on the water available per person per year (<1000 m^3/person/year). Water scarcity indicates that a population is dependent on water resources from outside their immediate region (~85 km^2). While the majority of the population lives in the east of Botswana, the highest percentage of people suffering from water scarcity is in the warm, semi-arid to arid Ghanzi district.

PROBABILISTIC RISK ASSESSMENT FOR RISK MANAGEMENT

METRICS FOR RISK MANAGEMENT

Risk information may be used to put in place a broad range of activities to reduce risk. Such measures range from improving building codes and designing risk reduction measures, to undertaking macro-level risk assessments used to prioritise investments. Risk metrics help discern the risk contribution of different external factors (such as demographic growth, climate change, urbanization expansion, etc.). They also provide a net measure of progress in the implementation of disaster risk reduction policies.

Average Annual Loss (AAL) can be interpreted as an opportunity cost. This is because resources set aside to cover disaster losses could be used for development. Monitoring AAL in relation to other country economic indicators – such as the GDP, capital stock, capital investment, reserves, and social expenditure – provides an indication of a country's fiscal resilience, broadly defined as comprising internal and external savings to buffer against disaster shocks. Economies can be severely disrupted if there is a high ratio of AAL to the value of capital stock. Similarly, future economic growth can be compromised if there is a high ratio of AAL to capital investment and reserves. Social development will be challenged if there is a high ratio of AAL to social expenditure. Moreover, limited ability to recover quickly may significantly increase indirect disaster losses. Countries that already have compensatory mechanisms such as effective insurance in place and that can rapidly compensate for losses will recover far more quickly than those that do not. Such mechanisms may include insurance and reinsurance, catastrophe funds, contingency financing arrangements with multilateral finance institutions, and market-based solutions such as catastrophe bonds (UNISDR, 2011 and 2013).

The PML curve is particularly useful in order to articulate a full DRR strategy. The PML curve describes the loss that can be experienced for a given return period. Knowing the different level of losses expected on a certain frequency can help to understand how to organise a strategy combining different risk reduction, mitigation, or avoidance actions.

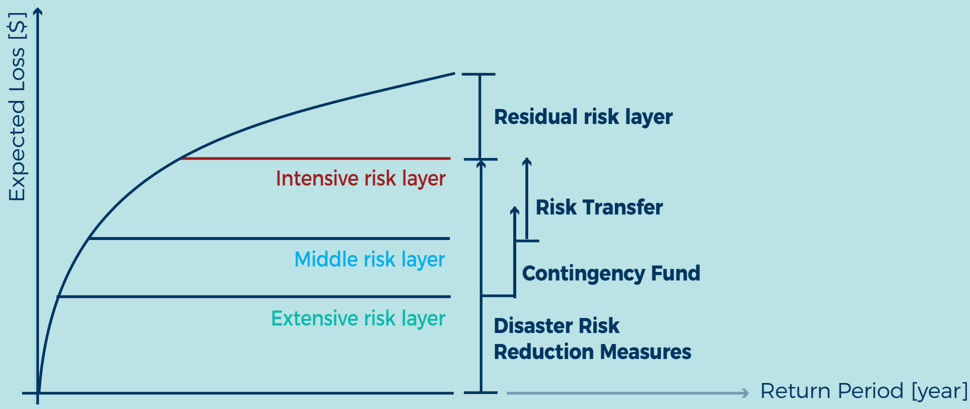
PML CURVE

The PML curve can be subdivided into three main layers. The Extensive Risk Layer is typically associated with risk reduction measures (e.g. flood defences, local vulnerability reduction interventions).

The Mid Risk Layer captures cumulative losses from higher impact events. Losses within this layer are commonly mitigated using financial funds which are managed at country level, such as the contingency fund.

Losses which constitute the Intensive Risk Layer (severe and infrequent hazard events) are difficult to finance at country level. Mechanisms of risk transfer are therefore required to address losses associated with this Intensive Risk layer (e.g. insurance and reinsurance measures).

The remaining layer of the curve is Residual Risk (catastrophic events). It is the risk that is considered acceptable/tolerable due to the extreme rarity of such events and associated loss levels. Given its rarity, there are no concrete actions to reduce risk beyond preparedness (e.g. civil protection actions, humanitarian aid coordination).



GLOSSARY & REFERENCES

AFFECTED PEOPLE and GDP
Affected people are the ones that may experience short-term or long-term consequences to their lives, livelihoods or health and in the economic, physical, social, cultural and environmental assets. In the case of this report "affected people from Floods" are the people living in areas experiencing a flood intensity (i.e. a flood water level) above a certain threshold. Analogously, in this report "affected people from Droughts" are the people living in areas experiencing a drought intensity (i.e. a SPEI value) below a certain threshold. The GDP affected has been methodologically defined using the same thresholds both for floods and droughts.

AVERAGE ANNUAL LOSS (AAL)*
Average Annual Loss (also Average Damage per year) is the estimated impact (in monetary terms or number of people) that a specific hazard is likely to cause, on average, in any given year. It is calculated based on losses (including zero losses) produced by all hazard occurrences over many years.

CLIMATE MODEL*
A numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for some of its known properties. Climate models are applied as a research tool to study and simulate the climate, and for operational purposes, including monthly, seasonal, and interannual climate predictions.

DISASTER RISK*
The potential loss of life, injury, or destroyed, or damaged assets which could occur to a system, society, or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability, and capacity.

DROUGHT
Droughts, defined as unusual and temporary deficits in water supply, are a persistent hazard, potentially impacting human and environment systems. Droughts, which can occur everywhere, should not be confused with aridity, a permanent climate condition.
In this profile drought hazard is denoted by various indicators, covering a range of drought types. Drought conditions are defined as months with standardised index values below a threshold varying between -0.5 and -2, according to the aridity index of that area. Humid areas have low thresholds, corresponding with the driest 2% of months as found in the period 1951-2000, while semi-arid and arid areas have thresholds linked to respectively the driest 6% and 15% of this reference period (assessed for each month separately).
Droughts are analysed in terms of hazard, exposed population, livestock and GDP, and losses are explicitly estimated for crop production and hydropower generation.

FLOOD*
Flood hazard in the risk assessment includes river (fluvial) flooding and flash flooding. This risk profile document considers mainly fluvial flooding and flash floods in the main urban centres. Fluvial flooding is estimated at a resolution of 90 m using global meteorological datasets, a global hydrological model, a global flood-routing model, and an inundation downscaling routine. Flash flooding is estimated by deriving susceptibility indicators based on topographic and land use maps. Flood loss curves are developed to define the potential damage to the various assets based on the modelled inundation depth at each specific location.

LOSS DUE TO DROUGHT (CROPS)
Economic losses from selected crops result from multiplying gross production in physical terms by output prices at farm gate. Losses in working days have been estimated as function of crop-specific labour requirements for the cultivation of selected crops. Annual losses have been computed at Admin 1 level as the difference relative to a threshold, when an annual value is below this threshold. The threshold equals the 20% lowest value from the period 1951-2000 and has also been applied for the future climate. Losses at national level have been estimated as the sum of all Admin 1 losses.

PROBABLE MAXIMUM LOSS (PML)*
PML is the value of the largest loss that could result from a disaster in a defined return period such as 1 in 100 years. The term PML is always accompanied by the return period associated with the loss.

RESIDUAL RISK*
The disaster risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained.

RESILIENCE*
The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.

RETURN PERIOD*
Average frequency with which a particular event is expected to occur. It is usually expressed in years, such as 1 in X number of years. This does not mean that an event will occur once every X numbers of years, but is another way of expressing the exceedance probability: a 1 in 200 years event has 0.5% chance to occur or be exceeded every year.

**UNISDR terminology on Disaster Risk Reduction: https://www.unisdr.org/we/inform/publications/7817*

GLOSSARY & REFERENCES

RISK*
The combination of the probability of an event and its negative consequences. While in popular usage the emphasis is usually placed on the concept of chance or possibility, in technical terms the emphasis is on consequences, calculated in terms of "potential losses" for some particular cause, place, and period. It can be noted that people do not necessarily share the same perception of the significance and underlying causes of different risks.

RISK TRANSFER*
The process of formally or informally shifting the financial consequences of particular risks from one party to another, whereby a household, community, enterprise, or State authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party.

**UNISDR terminology on Disaster Risk Reduction: https://www.unisdr.org/we/inform/publications/7817*

[1] https://www.climate-zone.com/climate/botswana/

[2] FAO Aquastat, Botswana, http://www.fao.org/nr/water/aquastat/countries_regions/BWA/

[3] Harris, I. P. D. J., Jones, P. D., Osborn, T. J., & Lister, D. H. (2014). Updated high-resolution grids of monthly climatic observations-the CRU TS3. 10 Dataset. International Journal of Climatology, 34(3), 623-642.

[4] https://www.mapsofworld.com/botswana/botswana-river-map.html

[5] https://www.worldatlas.com/webimage/countrys/africa/botswana/bwland.htm

[6] Alder, J. R., & Hostetler, S. W. (2015). Web based visualization of large climate data sets. Environmental Modelling & Software, 68, 175-180.

[7] Abba Omar, S. & Abiodun, B.J., How well do CORDEX models simulate extreme rainfall events over the East Coast of South Africa? Theor Appl Climatol (2017) 128: 453. https://doi.org/10.1007/s00704-015-1714-5

[8] Nikulin, G., Jones, C., Giorgi, F., Asrar, G., Büchner, M., Cerezo-Mota, R., ... & Sushama, L. (2012). Precipitation climatology in an ensemble of CORDEX-Africa regional climate simulations. Journal of Climate, 25(18), 6057-6078.

[9] Nikulin G, Lennard C, Dosio A, Kjellström E, Chen Y, Hänsler A, Kupiainen M, Laprise R, Mariotti L, Fox Maule C, van Meijgaard E, Panitz H-J, Scinocca J F and Somot S (2018) The effects of 1.5 and 2 degrees of global warming on Africa in the CORDEX ensemble, Environ. Res. Lett., doi:10.1088/1748-9326/aab2b4

[10] http://www.worldometers.info/world-population/botswana-population/

[11] Republic of Botswana CIA Factbook, https://www.cia.gov/library/publications/the-world-factbook/geos/bc.html

[12] WorldBank, http://www.worldbank.org/en/country/botswana/overview

[13] Keywan Riahi et al., The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview, Global Environmental Change, Volume 42, January 2017, Pages 153-168

[14] Richard H. Moss et al., The next generation of scenarios for climate change research and assessment, Nature volume 463, pages 747–756 (11 February 2010)

[15] Brian C. O'Neill et al., The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6, Geosci. Model Dev., 9, 3461–3482, 2016, doi:10.5194/gmd-9-3461-2016

The results presented in this report have been elaborated to the best of our ability, optimising the publicly data and information available. All geographic information has limitations due to scale, resolution, data and interpretation of the original sources.

www.preventionweb.net/resilient-africa

www.unisdr.org

RISK PROFILES ARE AVAILABLE AT:

africa.cimafoundation.org

This publication has been produced with the assistance of the European Union.
The contents of this publication are the sole responsibility of CIMA Research Foundation and can in no way be taken to reflect the views of the European Union.